LONDON-WEST MIDLANDS ENVIRONMENTAL STATEMENT

Volume 5 | Technical Appendices

CFA8 | The Chalfonts and Amersham

Water resources assessment (WR-002-008)

Water resources

November 2013

VOL 5

ES 3.5.2.8.13

LONDON-WEST MIDLANDS ENVIRONMENTAL STATEMENT

Volume 5 | Technical Appendices

CFA8 | The Chalfonts and Amersham

Water resources assessment (WR-002-008)

Water resources

November 2013

Department for Transport

High Speed Two (HS2) Limited has been tasked by the Department for Transport (DfT) with managing the delivery of a new national high speed rail network. It is a non-departmental public body wholly owned by the DfT.

A report prepared for High Speed Two (HS2) Limited.

High Speed Two (HS2) Limited,
Eland House,
Bressenden Place,
London SW1E 5DU

Details of how to obtain further copies are available from HS2 Ltd.

Telephone: 020 7944 4908

General email enquiries: HS2enquiries@hs2.org.uk

Website: www.hs2.org.uk

recycle

Printed in Great Britain on paper
containing at least 75% recycled fibre.

Contents

List of figures

List of tables

1 Introduction

1.1 Structure of the water resources and flood risk assessment appendices

1.1.1 The water resources and flood risk assessment appendices comprise four parts. The first of these is a route-wide appendix (Volume 5: Appendix WR-001-000).

1.1.2 Two specific appendices for each community forum area (CFA) are also provided. For the Chalfonts and Amersham area (CFA8) these are:

- a water resources assessment (i.e. this appendix); and
- a flood risk assessment (Volume 5: Appendix WR-003-008).

1.1.3 Maps referred to throughout the water resources and flood risk assessment appendices are contained in the Volume 5, Water Resources and Flood Risk Assessment Map Book.

1.2 Study area

1.2.1 CFA8 covers approximately 11.3km of the Proposed Scheme in the Chiltern District in the county of Buckinghamshire. The area extends from the M25, east of Chalfont St Peter in the south-east, to the junction of the A413 and Mop End Lane in the north-west.

1.2.2 The spatial scope of the assessment was based upon the identification of surface water features within 1km of the route except where there is clearly no hydraulic connectivity and in urban areas where the extent was 500m. Outside of these distances it is unlikely that direct impacts upon the water environment will be attributable to the Proposed Scheme. All groundwater bodies are considered within 1km laterally of the route and, where there is an aquifer, within 10m of the lowest possible construction or dewatering depth. For the purposes of this assessment this is defined as the study area.

1.2.3 The main environmental features of relevance to water resources include:

- the River Misbourne, its associated catchment and floodplain;
- Shardeloes Lake - an online lake on the River Misbourne;
- a number of identifiable ponds located outside the route alignment but within 1km of the route, together with numerous small agricultural ponds within 1km of the route; and
- licensed private and public water supply groundwater abstractions and associated source protection zones (SPZ).

1.2.4 Key environmental issues relating to water resources include:

- potential impacts on groundwater flow towards public water supplies (PWS) from tunnelling activities;

- the potential for an increase in flow losses from the River Misbourne and Shardeloes Lake to the Chalk aquifer as a result of settlement due to tunnelling activities; and
- the impact of dewatering during vent shaft construction on localised groundwater flows, and surface water levels and flows in the River Misbourne and Shardeloes Lake.

1.2.5 Where a residual impact or mitigation for water resources has a consequent effect on ecology, this is discussed further in Volume 2, CFA Report 8, The Chalfonts and Amersham (CFA report 8), Section 7.

2 Stakeholder engagement

2.1.1 Discussions have been held with the following stakeholders to inform the water resources assessment:

- the Environment Agency with regard to abstraction licenses and river diversions;
- the Misbourne River Action Group, the Chilterns Society and Buckinghamshire County Council concerning the River Misbourne and groundwater flooding as Lead Local Flood Authority;
- Affinity Water and a private abstraction licensee where the consultations have comprised:
  - informing the private licensee and requesting further information in a questionnaire to more accurately assess and understand any potential risks to the private abstraction; and
  - meetings with Affinity Water to discuss potential monitoring and mitigation options for PWS boreholes.

3 Baseline data

3.1 General

3.1.1 The following section provides a current description of water resources including surface water and groundwater.

3.1.2 All water bodies in this area fall within the London sub-catchment of the Thames River Basin District as defined under the Water Framework Directive[1] (WFD) and are covered by the River Basin Management Plan[2] (RBMP).

3.2 Surface water features

3.2.1 All surface water features within 1km of the route[3] are presented in Table 1.

3.2.2 The current surface water baseline and water features with codes listed in Table 1 are shown in Map WR-01-009 and WR-01-010 (Volume 5, Water Resources and Flood Risk Assessment Map Book). The map reference is in one of two forms. If the feature has a specific reference number then this is provided (e.g. a surface water crossing will be referenced as SWC-CFA05-001). If the feature has no specific reference its location on a specific map is provided (e.g. WR-01-005, D6) where D6 is a grid reference using the map specific grid.

3.2.3 The surface water features are based on the Environment Agency's Detailed River Network (DRN) with the addition of water bodies noted on the Ordnance Survey's (OS) '*OS VectorMapDistrict*.'

3.2.4 All water bodies within the study area, including the River Misbourne, fall within the Colne sub-catchment of the Thames River Basin District (RBD) and associated river basin management plan (RBMP).

[1] Water Framework Directive - Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, Strasbourg, European Parliament and European Council.
[2] River Basin Management Plan 2009, Thames River Basin District, Environment Agency.
[3] The Environment Agency's Detailed River Network (DRN) shows the route to cross a culverted watercourse (Map WR-01-002). The watercourse has been included in the DRN to ensure connectivity. It is considered that any such watercourse is a part of the sewer network and is not a surface water feature. It has therefore not been included in this assessment.

Table 1: Surface water features within 1km of the route in CFA8

Water feature	Location description (Volume 5 Water Resources and Flood Risk Map Book map reference)	Watercourse classification[4]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[5]	$Q95^6$ (m^3/s)	Catchment area at crossing (km^2)	Notes
Unnamed drain east of Chalfont St Peter	Isolated field drain to the south of the route (750m) east of Chalfont St Peter.	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The unnamed drain is not connected to any other surface water features in the catchment.
Unnamed pond at Three Oaks Farm	Isolated field pond to the north of the route (120m) near Three Oaks Farm. (CFA8P1)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The pond is not connected to any other surface water features in the catchment.
Seven unnamed ponds at Horn Hill	Isolated field ponds to the north of the route (from 120 - 700m) near Horn Hill. (CFA8P2)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The ponds are not connected to any other surface water features in the catchment.
Unnamed pond No.1 north of Chalfont St Peter	Isolated field pond adjacent to the south of the route (within 25m), north of Chalfont St Peter. (CFA8P3)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The pond is not connected to any other surface water features in the catchment.

[4] Water-feature classifications: Section 113 of the Water Resources Act 1991 defines a main river as a watercourse that is shown as such on a main river map. Section 72 of the Land Drainage Act 1991 defines an ordinary watercourse as 'a watercourse that is not part of a main river'. Section 221 of the Water Resources Act 1991 defines a watercourse as including 'all rivers and streams, ditches, drains, cuts, culverts, dikes, sluices, sewers (other than public sewers) and passages through which water flows'. Main rivers are larger rivers and streams designated by Defra on the main river map and are regulated by the Environment Agency

[5] For examples of receptor value, see Table 43 in the Scope and Methodology Report (SMR) Addendum, Volume 5: Appendix CT-001-000/2.

[6] Q95 is the flow which is exceeded for 95% of the time (i.e. it is a low flow and the river will only have flows less than this for 5% of the time).

Water feature	Location description (Volume 5 Water Resources and Flood Risk Map Book map reference)	Watercourse classification[4]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[5]	Q95[6] (m^3/s)	Catchment area at crossing (km^2)	Notes
Unnamed pond No.2 north of Chalfont St Peter	Isolated field pond to the north of the route (50m), north of Chalfont St Peter. (CFA8P4)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The pond is not connected to any other surface water features in the catchment.
Two unnamed ponds near Model Farm	Isolated field ponds to the north of the route (460 and 580m), near Model Farm. (CFA8P5)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The ponds are not connected to any other surface water features in the catchment.
Unnamed pond near Skipping's Farm	Isolated field pond to the south of the route (50m), near Skipping's Farm. (CFA8P6)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The pond is not connected to any other surface water features in the catchment.
Five unnamed ponds in Newland Park	Five Isolated field ponds to the north of the route (between 720-930m), in Newland Park. (CFA8P7)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The ponds are not connected to any other surface water features in the catchment.
Three unnamed ponds at Ashwells Farm	Isolated field ponds to the north of the route (between 225 - 400m), near Ashwells Farm. (CFA8P8)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The ponds are not connected to any other surface water features in the catchment.

Water feature	Location description (Volume 5 Water Resources and Flood Risk Map Book map reference)	Watercourse classification[4]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[5]	Q95[6] (m^3/s)	Catchment area at crossing (km^2)	Notes
Two unnamed ponds at Shrubs Cottage	Isolated field ponds to the north of the route (950m), at Shrubs Cottage. (CFA8P9)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The most eastern pond of the two has two drains running from it but they are not connected to any other surface water features in the catchment.
Unnamed pond near Gorelands	Isolated field pond to the north of the route (630m), to the north of Gorelands. (CFA8P10)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The pond is not connected to any other surface water features in the catchment.
River Misbourne	Will be crossed by the route twice; east of Chalfont St Giles (SWC-CFA8-01) and north of Shardeloes (SWC-CFA8-02). There are also two ponds connected to the channel approximately 60m south of crossing SWC-CFA8-01.	Main river	Misbourne GB106039029830 Poor	Good Potential	High	0.048 (SWC-CFA8-01) 0.014 (SWC-CFA8-02)	Colne 74.97 (SWC-CFA8-01) Colne 47.41 (SWC-CFA8-02)	The Misbourne is a lowland chalk stream that drains southwards from the Chilterns to its confluence with the River Colne. It has been designated by the EA as a Heavily Modified Water Body (HMWB) due to physical alterations by human activity
Unnamed pond at The Vache	Isolated field pond to the north of the route (960m), at The Vache. (CFA8P11)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The pond is not connected to any other surface water features in the catchment.

Water feature	Location description (Volume 5 Water Resources and Flood Risk Map Book map reference)	Watercourse classification[4]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[5]	Q95[6] (m^3/s)	Catchment area at crossing (km^2)	Notes
Eight unnamed ponds to the west of Chalfont St Giles	Group of approximately eight i isolated field ponds to the south of the route (between 35 - 680m), in the area between Chalfont St Giles and Welpley's Wood. (CFA8P12)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The ponds are not connected to any other surface water features in the catchment.
Two unnamed ponds near Welpley's Wood	Two isolated field ponds to the south of the route (620 and 780m), west of Welpley's Wood. (CFA8P13)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The ponds are not connected to any other surface water features in the catchment.
Two unnamed ponds at Brentford Grange Farm	Isolated field ponds to the south of the route (800m), at Brentford Grange Farm. (CFA8P14)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The ponds are not connected to any other surface water features in the catchment.
Moat near Brentford Grange Farm	Moat to the south of the route (650m), near Brentford Grange Farm.	Not applicable	Not applicable	Not applicable	Moderate	Not applicable	Not applicable	The moat is not connected to any other surface water features in the catchment.
Unnamed pond near Quarrendon Farm	Isolated field pond to the north of the route (430m), near Quarrendon Farm. (CFA8P15)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The pond is not connected to any other surface water features in the catchment.

Water feature	Location description (Volume 5 Water Resources and Flood Risk Map Book map reference)	Watercourse classification[4]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[5]	Q95[6] (m^3/s)	Catchment area at crossing (km^2)	Notes
Unnamed pond within David's Wood	Isolated pond to the south of the route (90m), within David's Wood. (CFA8P16)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The pond is not connected to any other surface water features in the catchment.
Five unnamed ponds near Rushymead	Five ponds to the south of the route (between 500 - 700m), near Rushymead. (CFA8P17)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The ponds are not connected to any other surface water features in the catchment.
Four unnamed ponds Cherry Tree Farm	Four ponds to the south of the route (between 530 - 940m), near Cherry Tree Farm (north of Coleshill). (CFA8P18)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The ponds are not connected to any other surface water features in the catchment.
Two unnamed ponds within Rodger's Wood	Isolated ponds to the north of the route (270m), within Rodger's Wood. (CFA8P19)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The ponds are not connected to any other surface water features in the catchment.
Shardeloes Lake	Shardeloes Lake is adjacent to and north of the route (within 300m). (CFA8P20)	Main river	Misbourne GB106039029830 Poor	Good Potential	High	Not applicable	Not applicable	The lake, approximately 0.07km in area, is part of the River Misbourne which flows west to east through the lake. The lake is used for recreational purposes with a Boat House on the eastern shore.

Water feature	Location description (Volume 5 Water Resources and Flood Risk Map Book map reference)	Watercourse classification[4]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[5]	Q95[6] (m^3/s)	Catchment area at crossing (km^2)	Notes
Three unnamed ponds in Upper Park	Isolated ponds to the south of the route (785m – 1km), within Upper Park. (CFA8P21)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The ponds are not connected to any other surface water features in the catchment.

3.2.5 There are no surface water abstractions within 1km of the route in the study area[7]. There is the potential for unlicensed abstractions to exist, as a licence is not required for abstraction volumes below 20m³ per day. Historically, however, flows in the River Misbourne have been impacted by groundwater abstractions (see Table 3 for groundwater abstraction licenses). This is especially the case in the area between Amersham and Chalfont St Giles and further downstream to Chalfont St Peter. In this area the river is often 'perched' (i.e. the groundwater level is below the base of the river) and loses flow to groundwater.

3.2.6 Table 2 summarises surface water discharge consents within 1km of the route.

Table 2: Surface water discharge consents

Reference number	Permit identifier	Distance (and direction) from route (in metres)	Discharge type	Receiving water feature
CFA8-WD98	TEMP.1611	359 (south-west)	Sewage discharge - pumping station	River Misbourne

3.3 Groundwater

3.3.1 A summary of the geological units present within the Chalfonts and Amersham area along with their hydrogeological characteristics is presented in Volume 2, CFA Report 8, Section 13.3.

3.3.2 Map WR-02-008 (Volume 5, Water Resources and Flood Risk Assessment Map Book) illustrates the spatial distribution of the uppermost superficial and bedrock formations within the study area.

Superficial deposits

3.3.3 At the southern end of the route, superficial deposits comprise sand and gravel or river alluvium associated with the River Misbourne. Superficial deposits are generally absent from the northern half of the route section although a small area of clay with flints is evident to the west of Amersham Old Town. The route will also cross an area of head deposits, described as gravel, that outcrops along Whielden Lane extending under the hospital and towards Amersham Old Town as illustrated in Map WR-02-008 (Volume 5, Water Resources and Flood Risk Assessment Map Book).

Bedrock geology

3.3.4 Bedrock geology comprises Cretaceous White Chalk (a soft limestone) and the Lambeth Group comprising clays, silts and sands, outcropping where it overlies the White Chalk.

3.3.5 The regional hydrogeological map shows that the very low Chalk groundwater levels measured in autumn 1976 (known to be a regional drought period) were 57m above

[7] Surface water abstractions for public supply are not included.

Ordnance Datum (m AOD) (at Chalfont St Peter) rising to 91.5m AOD near Amersham (at the boundary between the Chalfonts and Amersham area and the Central Chilterns area (CFA9)). The map indicates the direction of groundwater flow within the vicinity of the route to be towards the southeast as shown in Figure 1. Other groundwater level data such as the South West Chilterns Groundwater Model[8] and data provided by Affinity Water support this conclusion.

3.3.6 The Environment Agency borehole monitoring data indicates that maximum recorded groundwater levels were measured in winter 2000/2001 at 67m AOD at Chalfont St Peter, rising to 97m AOD near Amersham (at the boundary between the Chalfonts and Amersham area and Central Chilterns area). This suggests that peak groundwater levels will be approximately 20-30m are above the tunnel elevation. The tunnel elevation will be between 37.6m AOD near Chalfont St Peter, 59.8m AOD near Amersham and 78.1m AOD near Little Missenden along the route in this area.

3.3.7 The hydrographs on Figure 2 indicate groundwater elevations at sites monitored by the Environment Agency in the vicinity of the River Misbourne.

3.3.8 A cross-section of the geological strata is provided in Figure 3 also including the groundwater elevations where known (or inferred) and the depth of the scheme.

3.3.9 Groundwater flow in the Chalk is expected to be through discrete fractures which may be laterally persistent where they have formed in a particular geological layer. The base of the Lewes Nodular Chalk Formation/top of the New Pit Chalk Formation (often referred to as the Chalk Rock in old water well records) often contains more fractures and flow than the strata immediately above and below. Another zone of preferential flow often occurs in the Melbourne Rock at the base of Holywell Chalk Formation / top of the Grey Chalk Subgroup which underlies the White Chalk Subgroup.

[8] Atkins, (2007). *South West Chilterns Phase 1 Conceptual Model Final Report*

Figure 1: Groundwater level contours for the Chalk aquifer for CFA8 and the surrounding areas

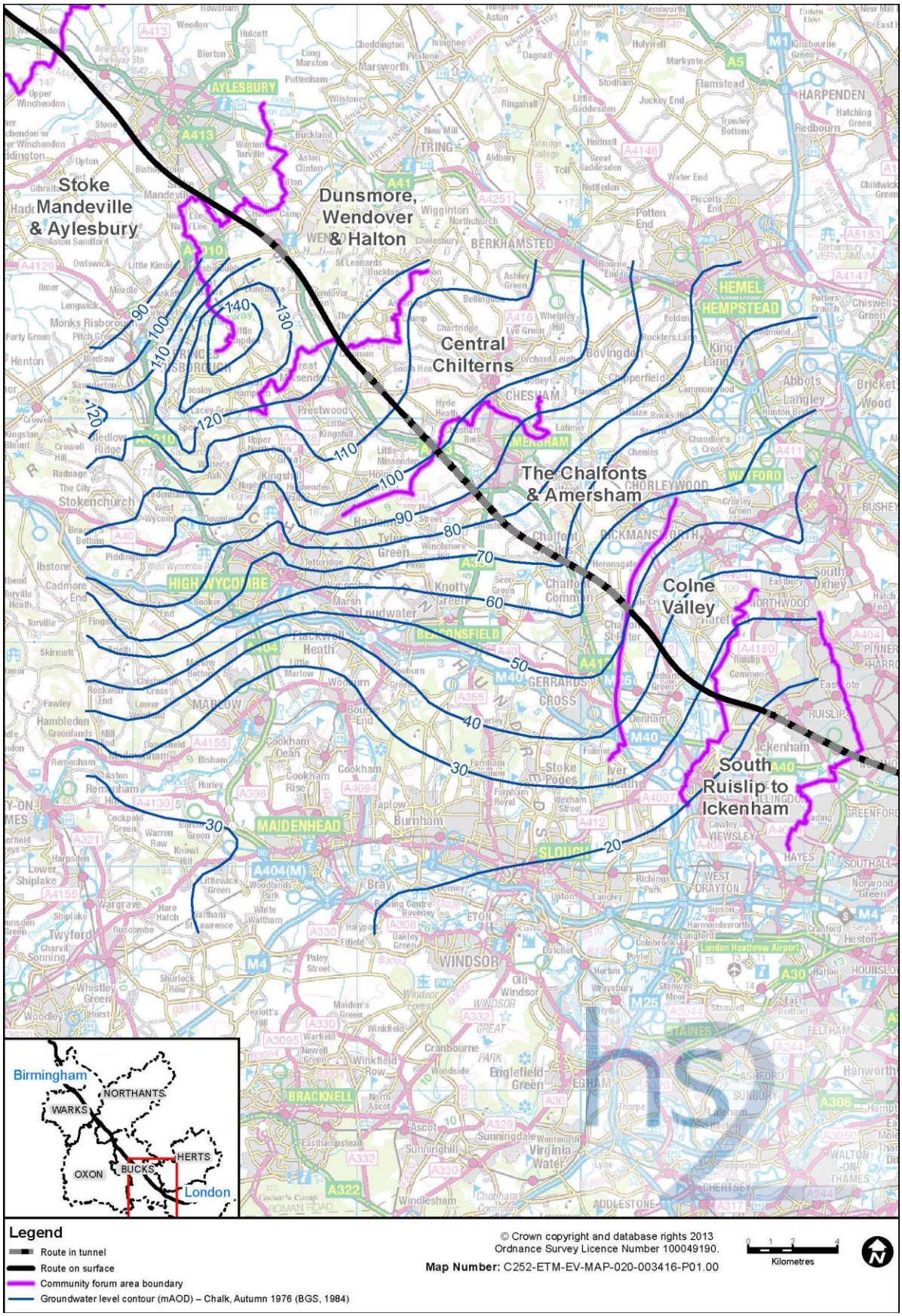
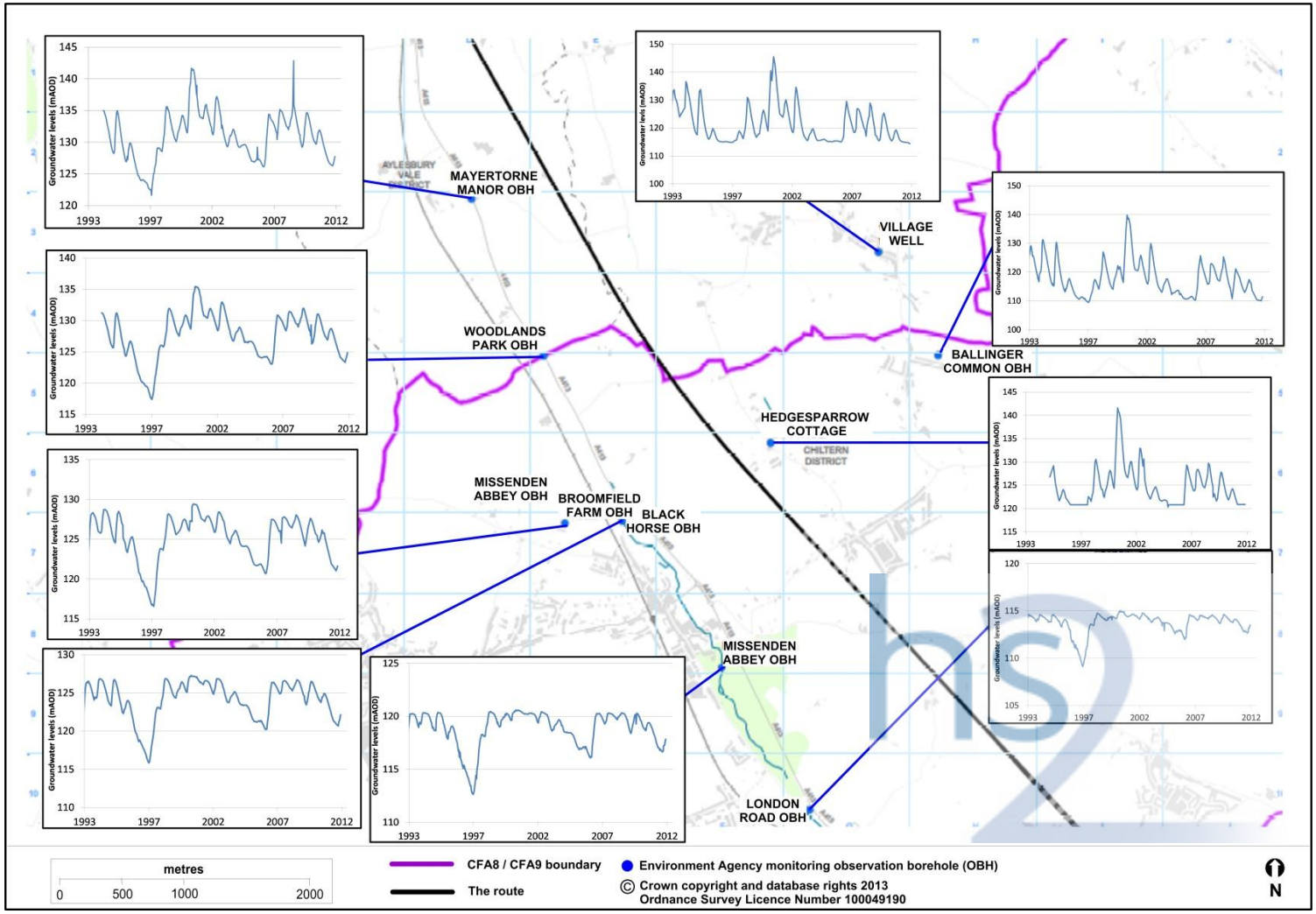


Figure 2: Groundwater hydrographs illustrating seasonal fluctuations for the area within CFA8 between 1993 and 2013.



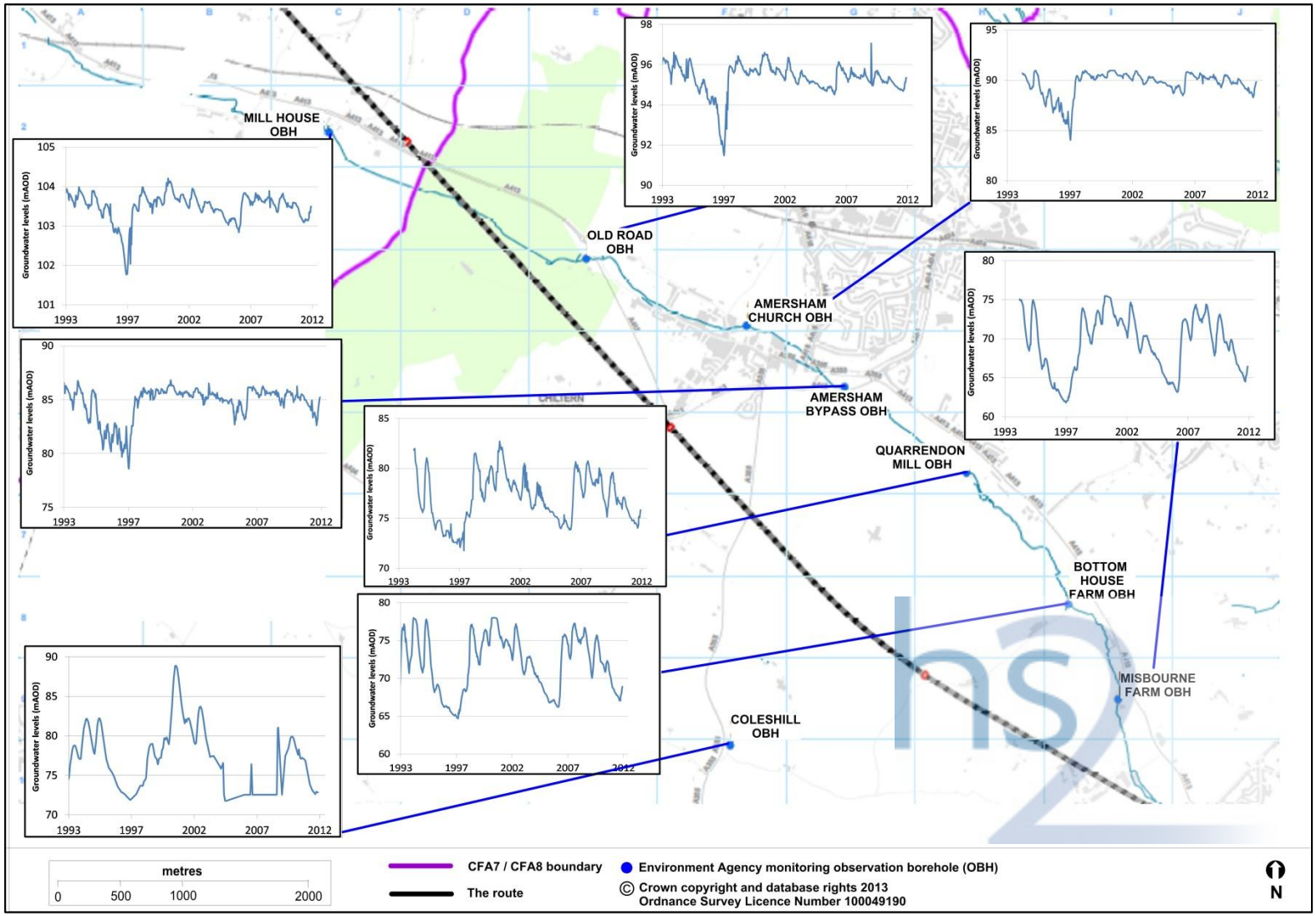
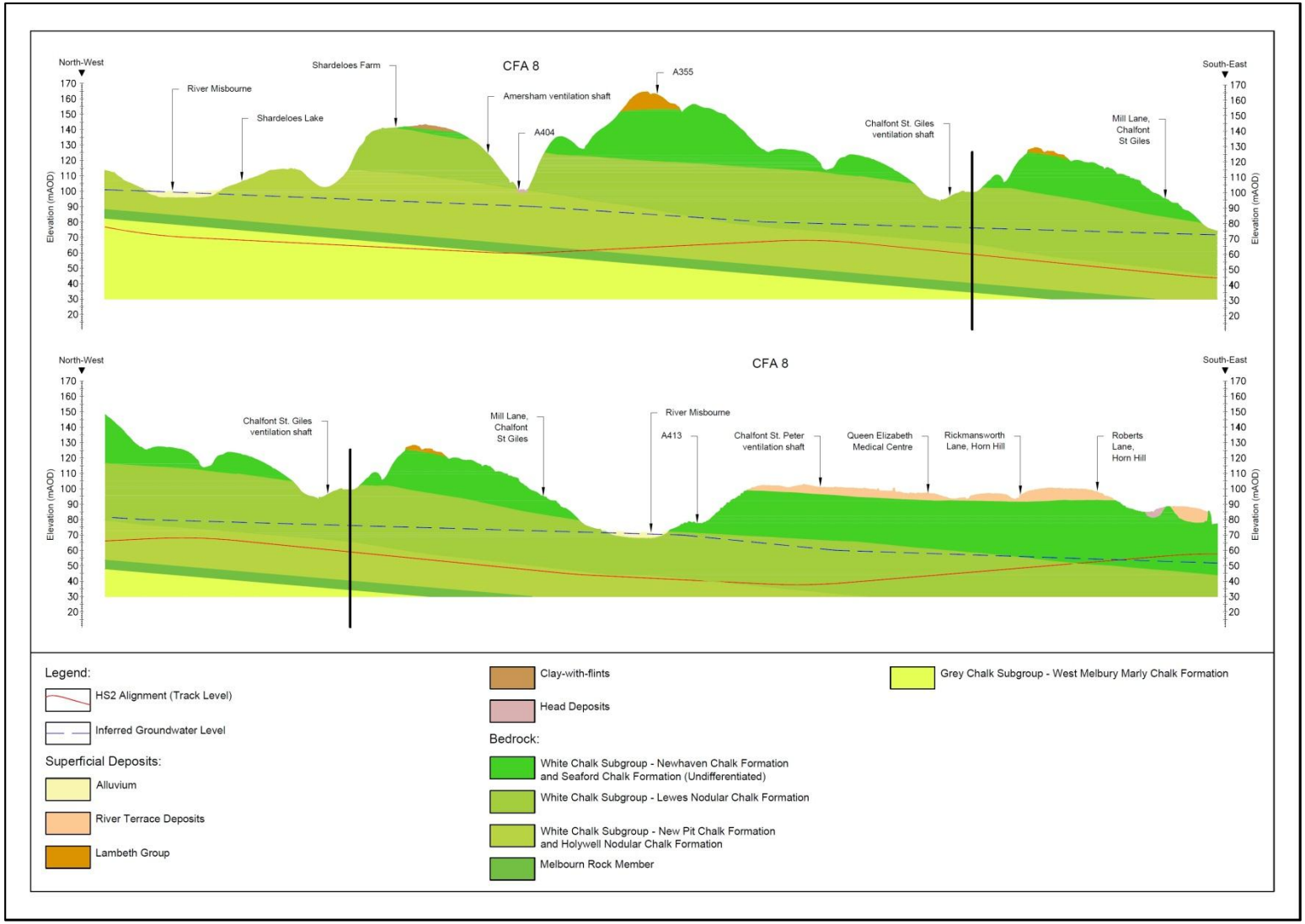

MILL HOUSE OBH
OLD ROAD OBH
AMERSHAM CHURCH OBH
AMERSHAM BYPASS OBH
QUARRENDON MILL OBH
BOTTOM HOUSE FARM OBH
MISBOURNE FARM OBH
COLESHILL OBH
Groundwater levels (mAOD)
1993
1997
2002
2007
2012
metres
0
500
1000
2000
CFA7 / CFA8 boundary
The route
Environment Agency monitoring observation borehole (OBH)
© Crown copyright and database rights 2013
Ordnance Survey Licence Number 100049190
N

Figure 3: Schematic cross section of geology and route in CFA8.



3.3.10 Table 3 summarises licensed groundwater abstractions within 1km of the route. There is a complex distribution of source protection zones (SPZ) associated with PWS within the study area. There is the potential for further unlicensed abstractions to exist, as a licence is not required for abstraction volumes below 20m³ per day.

Table 3: Licensed groundwater abstractions

Licence identifier (map reference number and Environment Agency reference)	**Distance and direction from route (m)**	**Abstraction horizon**	**Maximum annual abstraction quantity (m^3)**	**Maximum daily abstraction quantity (m^3/d)**	**Purpose**	**Number of boreholes**
Public water supplies (the reference number identifies the relevant SPZ1 on the maps)						
TH027 (licence identifier confidential)	327m east (source in the Colne Valley area, CFA7) (SPZ2 will be crossed by route in CFA8)	Chalk	32,120,000 (includes five sources)	18,184	PWS	Three
TH171 (licence identifier confidential)	950m east (CFA7) (SPZ1 & 2 will be crossed by route in CFA8)	Chalk	32,120,000 (includes five sources)	20,457	PWS	Two
TH181 (licence identifier confidential)	200m north-east (SPZ2 will be crossed by route in CFA8)	Chalk	1,460,000	4,546	PWS	Unknown
TH028 (licence identifier confidential)	2,740m south-west (SPZ2 will be crossed by route in CFA8)	Chalk	Unknown	Unknown	PWS	Unknown
TH011 (licence identifier confidential)	985m north-east (SPZ2 will be crossed by route in CFA8)	Chalk	2,555,000	18,184	PWS	Unknown
Private licensed water supplies						
GW8 (28/39/28/0109)	703m north-east	Chalk	19,093	227	Textiles & leather, process water	Unknown
Private unlicensed water supplies						
CFA8-GWUA03	315m south-west	Chalk	Unknown	Unknown	Farm, use unknown	Unknown
CFA8-GWUA02	610m south-west	Chalk	Unknown	Unknown	Assumed to be domestic	Unknown

3.3.11 In this area, there is a large area designated by the Environment Agency as SPZ2, with two smaller areas designated SPZ1 around PWS sources which are to the north-east of the River Misbourne. The SPZ mapping is taken to be indicative rather than definitive on the pathways and times of travel within the aquifer to the groundwater sources.

3.3.12 East of Chalfont St Peter the route in this area will cross the total SPZ which refers to PWS sources that are located in the adjacent Colne Valley area (CFA7). In the Chalfonts and Amersham area the route crosses approximately 4km of the combined SPZ2 for TH027 and TH171 around 600m of SPZ1 reference TH171.

3.3.13 North of Chalfont St Giles the route crosses the SPZ2 approximately 7km north-west of the PWS referenced TH028 which is located to the east of Gerrards Cross approximately 3.5km south of the route. The SPZ1 and 2 are elongated in shape and extend a substantial distance along the southern side of the valley of the River Misbourne.

3.3.14 PWS TH181 is located in the valley of the River Misbourne north east of Chalfont St Giles. Although the route passes approximately 200m south of the PWS it does not cross either SPZ 1 or SPZ 2 which fall within the large designated area extending along the northern side of the river.

3.3.15 PWS TH011 is located at the southern end of Amersham, east of Amersham Old Town, in the valley of the River Misbourne. At its closest point the source is approximately 1km north of the route but on the opposite side of the River Misbourne. The route does not cross the SPZ1 but does pass into the large area designated SPZ2 where the route crosses under the river close to Shardeloes Lake. The route remains within the SPZ2 for several kilometres after passing into Central Chilterns (CFA9).

3.3.16 A summary of groundwater discharge permits to groundwater directly or via land, within 1km of the route and their reference codes are listed in Table 4 and are shown in Map WR-02-008 (Volume 5, Water Resources and Flood Risk Assessment Map Book).

Table 4: Groundwater discharge consents

Reference number	Permit identifier	Distance (and direction) from route (m)	Discharge type	Receiving strata/water body
CFA8WD34	CNTM.1348	955m south-west	Sewage discharges - final/treated effluent - not water company (domestic)	Chalk
CFA8WD39	CTWC.3435	870m south-west	Sewage discharges - final/treated effluent - not water company (domestic)	Chalk
CFA8WD52	CTCU.0618	235m south-west	Sewage discharges - final/treated effluent - not water company (undefined)	Chalk
CFA8WD54	CTCU.0965	825m north-east	Sewage discharges - final/treated effluent - not water company (domestic)	Chalk

Reference number	Permit identifier	Distance (and direction) from route (m)	Discharge type	Receiving strata/water body
CFA8WD79	Canm.0506	105m south-west	Sewage discharges - final/treated effluent - not water company (domestic)	Into land
CFA8WD80	Canm.0507	65m south-west	Sewage discharges - final/treated effluent - not water company (domestic)	Into land
CFA8WD83	Canm.0691	575m north-east	Sewage discharges - final/treated effluent - not water company (domestic)	Land via soakaway
CFA8WD84	Ctwc.3388	715m south-west	Sewage discharges - final/treated effluent - not water company (domestic)	Glacial sands and gravels
CFA8WD86	Canm.0857	615m south-west	Sewage discharges - final/treated effluent - not water company (domestic)	Into land via borehole
CFA8WD91	Cntw.0191	540m north-east	Sewage discharges - final/treated effluent - not water company (recreational and cultural)	Glacial gravels
CFA8WD96	Ctwc.2760	540m north-east	Sewage discharges - final/treated effluent - not water company (domestic)	Alluvium
CFA8WD97	Npswqd000877	110m south-west	Sewage discharges - final/treated effluent - not water company (domestic)	Land via borehole
CFA8WD100	Temp.2493	895m south-west	Public sewage: storm sewage overflow	Land
CFA8WD102	Npswqd009707	400m north-east	Sewage discharges - final/treated effluent - not water company (domestic)	Groundwater via a borehole
CFA8WD103	Canm.0334	500m north-east	Sewage discharges - final/treated effluent - not water company (domestic)	Land

3.4 Surface water/groundwater interaction

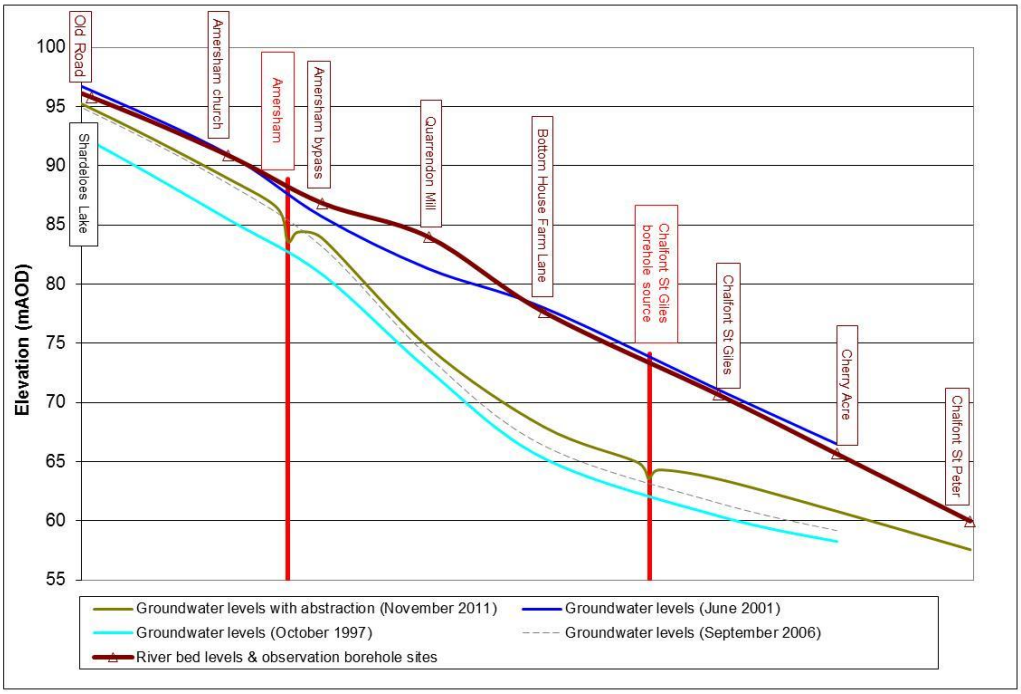
3.4.1 Table 5 summarises the surface water/groundwater interactions within 1km of the route.

Table 5: Surface water/groundwater interaction

Location description	Distance (m) and direction from route	Formation	Approximate elevation (metres above ordnance datum, mAOD)	Comments
River Misbourne (Map WR-01-009, D6) (Map WR-01-010, C/D5)	Will be crossed by route in tunnel at two locations SWC-CFA8-01 SWC-CFA8-02	Alluvium/ Chalk	75 (Chalfont St Giles)	There is moderate to good hydraulic connectivity between the river and groundwater in the Chalk along much of the river course, with the general exception of the reach from Amersham to Chalfont St Peter where perching occurs. Gaining and losing reaches are complex and can vary seasonally.
Shardeloes Lake (Map WR-01-010, D5)	One tunnel will pass under the south west, upstream corner	Alluvium/ Chalk	100	Hydraulic connectivity between the groundwater in the Chalk and Shardeloes Lake is possible although fine sediment and organic material is expected. The River Misbourne, which is groundwater fed, flows through the lake.

3.4.2 The interaction of the surface water and groundwater is complex as shown in Figure 4. In dry weather, groundwater levels can be around 10m lower than the river level in the reach between Amersham and Chalfont St Peter and this can lead to the river progressively drying downstream.

Figure 4: Schematic cross section of River Misbourne and groundwater levels



3.5 Water dependent habitats

3.5.1 The route will cross the River Misbourne which has a local biodiversity action plan habitat (refer to Volume 2, CFA Report 8, Section 7 for further details). The river is fed by groundwater from the Chalk aquifer.

3.5.2 Shardeloes Lake is considered a local wildlife site (LWS) and is designated for open standing water.

3.5.3 Table 6 summarises the water dependent habitats within 1km of the route.

Table 6: Description of water dependent habitats

Name/Location	Distance	Designation	Comments
River Misbourne	Will be crossed by the route at two locations SWC-CFA8-01 SWC-CFA8-02	Local biodiversity action plan.	Important habitat for aquatic invertebrates and a valuable habitat corridor for bats, birds and aquatic mammals.
Shardeloes Lake	Will be crossed by the route.	LWS (local biodiversity action plan habitat).	Designated for standing water and diverse assemblage of wintering birds.

4 Site specific surface water assessment

4.1 Summary of assessment

4.1.1 Table 7 summarises all potential impacts and effects to surface water features from the Proposed Scheme in the study area. Only those impacts and effects that are classed as significant are presented in Volume 2, CFA Report 8, Section 13.4.

4.1.2 Table 7 only includes water features which could potentially be impacted by the Proposed Scheme. Features such as isolated ponds and drains which will lie outside the construction footprint and area of impact of the Proposed Scheme, i.e. up to 1km from the Proposed Scheme, are not included. Details of these features are, however, provided in Table 1.

4.1.3 The draft Code of Construction Practice (CoCP), referred to in Table 7, sets out the measures and standards of work that will be applied to the construction of the Proposed Scheme (see Volume 5: Appendix CT-003-000/1). These will provide effective management and control of the impacts during the construction period.

Table 7: Summary of potential impacts to surface water

Surface water feature/receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Two unnamed ponds at Shrubs Cottage	Low	Chiltern tunnel	Due to the significant distance from the route and nature of the design element (tunnel), this receptor will not be impacted by the Proposed Scheme.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	None	None	Not applicable
River Misbourne SWC-CFA8-01 SWC-CFA8-02	High	Chiltern tunnel	Tunnel construction underlying the River Misbourne will result in settlement with a low risk of increased vertical permeability in base of River Misbourne potentially causing loss in flow. See section 4.2 of this report.		Enhanced monitoring of ground level, river flows and groundwater interaction to confirm low risk of loss of water from river.	Negligible Neutral Effect (Not significant) However, small risk of effects arising from settlement require further mitigation.	Bed sealing measures only if required.	Negligible impact to surface water Neutral effect (Not significant)	Construction (temporary)

Surface water feature/receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
River Misbourne	High	Vent shafts at Chalfont St Peter, Chalfont St Giles and Amersham	Modest requirement for construction water (from potable supply) and drainage (to local sewers). Polluting materials in runoff.	Negligible impact Neutral effect (Not significant)	Monitoring during construction CoCP measures to control sediment mobilisation and risk of spills.	Negligible impact Neutral effect (Not significant)	None	None	Construction (temporary)
Shardeloes Lake	High	Chiltern tunnel	Tunnel results in settlement and with a low risk of increased vertical permeability in base of River Misbourne and Shardeloes Lake causing a decrease in water level in the lake. See section 4.2 of this report.	Negligible impact Neutral effect (Not significant)	Enhanced monitoring of lake water level, river flows to confirm low risk of loss of water from river.	Negligible impact Neutral effect (Not significant)	Bed sealing measures only if required.	Negligible impact Neutral effect (Not significant)	Construction (temporary)

4.2 Detailed assessments

Assessment of potential impacts of surface water crossings

4.2.1 The locations and descriptions of the surface water crossing in the study area are given in Table 8.

Table 8: Summary of potential impacts to surface water

Water feature	Crossing	Description	Length (m)	WFD Water body, designation and status
River Misbourne	SWC-CFA8-01	Chiltern tunnel (bored under river channel)	Not applicable	Misbourne, (GB106039029830) Moderate
River Misbourne	SWC-CFA8-02	Chiltern tunnel (bored under river channel)	Not applicable	Misbourne, (GB106039029830) Moderate

4.2.2 The crossings listed in Table 8 cannot be avoided for the construction of the tunnel, with both temporary and permanent effects. The approach will therefore be to minimise the impact on water quality, flow and drainage as described in more detail in Section 5.2 of this report and water dependent ecological receptors as addressed in Volume 2, CFA Report 8, Section 7.

Highway drainage

4.2.3 Widening of one minor road (Bottom House Farm Lane) is required as part of the scheme in this area. This has the potential to cause minor temporary and permanent impacts on water quality in receiving groundwater. The road drainage is assumed to infiltrate into the ground through infiltration ponds/basins or as off-the-pavement runoff and thus eventually will reach the water table in the White Chalk aquifer. Appropriate mitigation will be selected using the Design Manual for Roads and Bridges (2013)[9] and the construction industry research and information association (CIRIA) guidance[10]. Residual impacts are likely to have neutral significance as a result.

Impacts of potential settlement on surface water/groundwater interactions

4.2.4 The Proposed Scheme would pass under the River Misbourne twice within the study area; immediately east of Chalfont St Giles (SWC-CFA8-01) and north of Shardeloes Lake (SWC-CFA8-02). The tunnel depth at these locations will be such that there is approximately two tunnel diameters of cover above the crown of the tunnel. The

[9] Department for Transport (2013). *Design Manual for Roads and Bridges*. http://www.dft.gov.uk/ha/standards/dmrb/vol11/section3/hd4509.pdf
[10] Murname, E., Heap, A. and Swain, A., (2006). *C648 Control of Water Pollution from Linear Construction Sites*. CIRIA, London, UK.

depth will be determined during the detailed design. The exact tunnelling method has not been selected, however, it is assumed for the purpose of assessment that it will be a closed faced TBM where groundwater conditions require this to reduce the likelihood of environmental impacts.

4.2.4 Under natural groundwater conditions the River Misbourne would have a complex baseflow dominated flow regime, with some stretches gaining water from groundwater inflow, and other stretches loosing water to underlying aquifers. However abstraction along the valley for public water supply has disrupted the normal baseflow dominated flow regime, and there is an even more complex groundwater/surface water regime in existence. The Environment Agency is working to re-establish a more normal situation by working with Affinity Water to reduce abstraction for public water supply, allowing groundwater levels to recover to more natural elevations. This will mean the volume of flow in the river should increase and periods when the river is dry should reduce.

4.2.5 As shown in Figure 4 the river bed within the vicinity of Chalfont St Giles is frequently above groundwater elevations in the Chalk (i.e. when the river has water flowing down it the river is 'perched').

4.2.6 In the area around Chalfont St Giles, the river is often reported to be dry (as observed in autumn 2012 when the river was visited for this assessment), or losing water in this area. This is confirmation that the river bed is already permeable and will naturally lose water to the groundwater when groundwater elevations are below the river water elevations.

4.2.7 In the vicinity of Shardeloes Lake the river is expected to be generally in better connectivity with the underlying Chalk groundwater and unlikely to be perched for any significant period of time.

4.2.8 The extent to which the tunnelling could cause settlement has been determined using predicted settlement contours. The extent of impact has been defined based on the minimum settlement contours (i.e. 5mm) and the spatial distribution of the surface water feature (River Misbourne or Shardeloes Lake). The contours indicate that the potential settlement will not extend laterally more than approximately 20m either side of either tunnel. The assessment takes account of the extra length of watercourse potentially affected due to the skew of the crossings relative to the watercourse. Figure 5 indicates the potential extent of settlement at the Chalfont St Giles crossing under the River Misbourne. The figure suggests that there could be settlement from 5-30mm where the tunnel crosses under the River Misbourne, with an extent of impact of approximately 255m along the course of the river. The greatest settlement would occur where the Misbourne flows under the bridge by Pheasant Hill.

4.2.9 Figure 6 shows the potential extent of settlement at the crossing upstream of Shardeloes Lake. The figure indicates that the River Misbourne alone could be impacted along a stretch of up to 275m, with settlement from 5mm at the outer edges of the twin tunnels to 30mm close to the centre. The figure also indicates that a small pond, which is 24m in length, could be impacted together with a part of Shardeloes Lake which is closest to the route. The overall length that could be impacted

(including the River Misbourne, the small pond and Shardeloes Lake) could be approximately 535m.

Figure 5: Schematic illustration demonstrating settlement at the Chalfont St Giles crossing

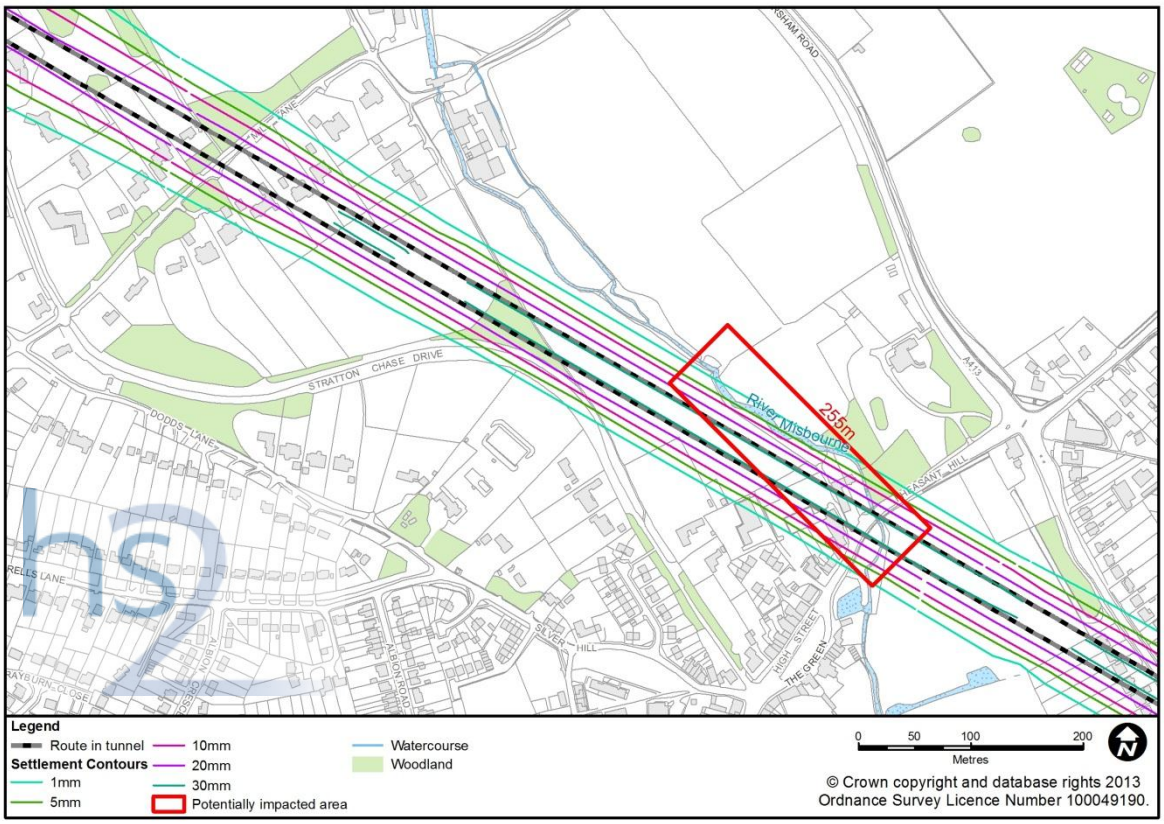
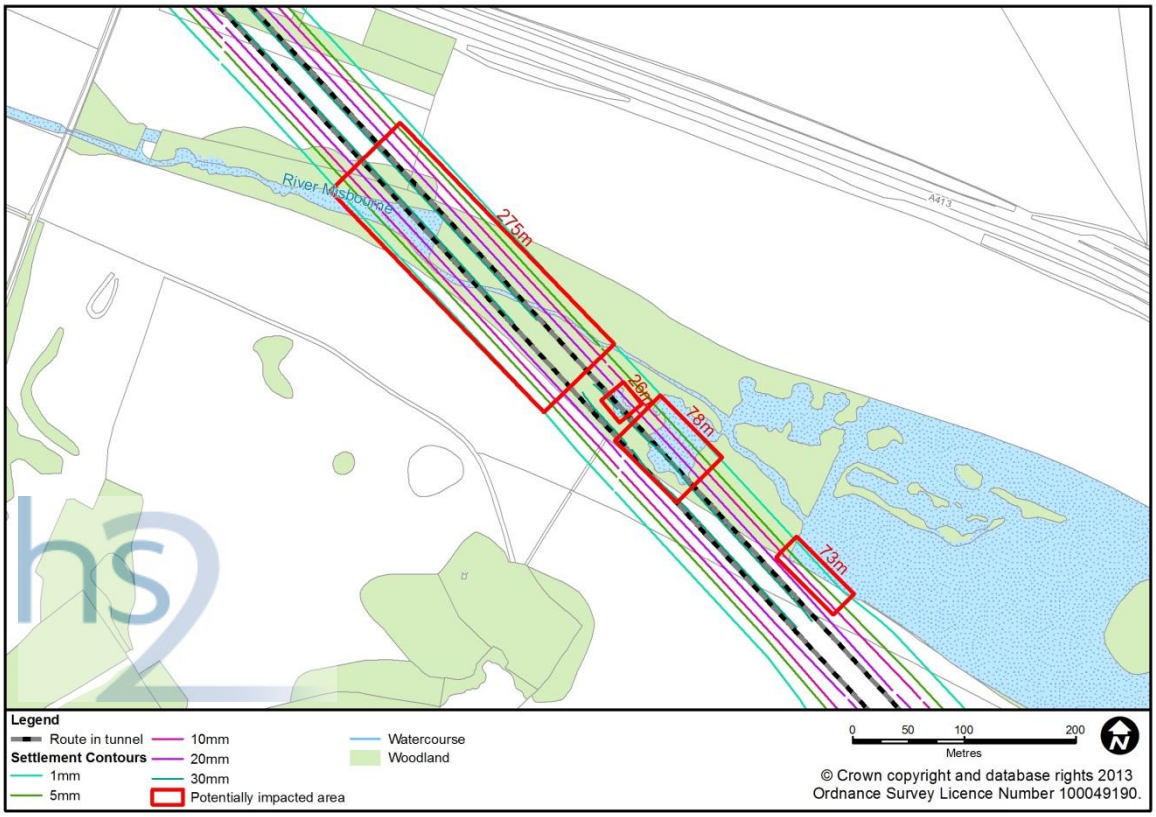


Figure 6: Schematic illustration demonstrating settlement at the crossing upstream of Shardeloes Lake



4.2.10 Within these settlement zones there is potential for existing fissures and cavities such as swallow holes to be enlarged or re-activated as hydraulic pathways. It is considered unlikely that any major new fissuring will occur across the whole "settlement zone" as the movement of the Chalk will simply be to move down in response to the excavation of the tunnel. The exception is where a void in the Chalk above the tunnel already exists, as the void could collapse as settlement occurs resulting in fracturing and disaggregation of overlying material as the void is filled from above. Some voids may be present in the vicinity of Chalfont St Giles within disaggregated weathered Chalk, which can have a thickness of up to 16m as indicated by Morigi et al. (2005)[11], but it is not possible to predict their presence without detailed ground investigations.

4.2.11 At Chalfont St Giles, if settlement increased the bed permeability then, when there was water in the River Misbourne, the rate of water loss could be increased to the underlying Chalk groundwater when the river was in a perched condition.

4.2.12 Near Shardeloes Lake the conditions could be more complex than at Chalfont St Giles. The river near Shardeloes Lake is generally in connectivity with Chalk groundwater and gaining flow since groundwater levels are at or above surface water level. The lake may also be in connectivity with the groundwater and gaining at the north end of the lake which is shown to be a wet boggy area, but potentially losing at the south end. The extent of connectivity of the lake with the groundwater could also depend on the nature and thickness of fine sediments which have been deposited in the lake. As a result of settlement there could be changes in the localised patterns of inflow to

11 Morigi et al. (2005), *Geology of the Beaconsfield District - A Brief Explanation of the Geological Map*; Sheet 255 Beaconsfield.

surface water from groundwater and possibly outflow from surface water to groundwater in very dry conditions. Overall, however, the groundwater/surface water interaction in the area around Shardeloes Lake would not be expected to change significantly due to the nature of the bed sediments and prevailing hydraulic gradient being upwards at the upstream end of the lake.

4.2.13 The scale of any impact that might arise from the construction of the Proposed Scheme will therefore be dependent on a number of factors - some of which vary over time. With this in mind, it should be noted that, under normal conditions, monitoring the river within the vicinity of Chalfont St Giles may not provide sufficient evidence of disturbance of the Chalk and loss of river flows as the river could be dry over this reach. Information will be required from monitoring data gathered up and down stream of the dry reach and from monitoring groundwater levels within the vicinity of the tunnel and River Misbourne. Geophysical and intrusive investigations will be undertaken prior to finalising the design of the tunnels. These will provide an indication of the geological and hydrogeological features present in the Chalk and the potential for significant disturbance of fissures and swallow holes or other solution features. This information will assist with defining appropriate mitigation, should the investigation and monitoring of groundwater levels and surface flows suggested that this would be required.

5 Site specific groundwater assessment

5.1 Summary of assessment

5.1.1 Table 9 summarises the potential impacts to hydrogeology (groundwater), abstractions, water dependent habitats and surface water/groundwater interactions. Only those impacts and effects that are classed as significant are presented in Volume 2, CFA Report 8, Section 13.4.

Table 9: Summary of potential impacts to groundwater receptors

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Hydrogeology (groundwater)									
Chalk Principal aquifer	High	Chiltern tunnel Cross passages	Dewatering during construction of the tunnel and cross passages could impact groundwater quality and flows.	Minor impact Moderate effect (Significant)	The tunnel construction methodology would be selected to avoid significant groundwater ingress to the tunnels and the need for major dewatering. Any dewatering effluents (groundwater) at cross passages would be pumped for short periods (up to three months) and discharged to ground (e.g. through soakage areas) where possible, under consent from the Environment Agency. Ground improvement and groundwater control at some cross passages would be undertaken below ground.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction (temporary)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Chalk Principal aquifer	High	Chiltern tunnel Chalfont St Giles, Chalfont St Peter and Amersham vent shafts	Tunnelling and shaft construction will have the potential to impact on groundwater quality due to the introduction of bentonite and additives in circulating fluids for tunnel boring machines (TBM), piling and diaphragm walls, prior to completion with in-situ concrete and cement grouts and their associated additives. Other materials with potential to contaminate groundwater include hydraulic fluids and bearing greases in below ground machinery, as well as the tailskin grease used to prevent groundwater inflow prior to installation of the tunnel lining.	Minor impact Moderate effect (Significant)	Work would be carried out in accordance with the draft CoCP which would govern the use of materials that could come into contact with groundwater and reduce the risk at source to the extent practicable. The mitigation measures set out within the draft CoCP will also govern the provision of suitable site drainage. Choice of tunnelling methodology will be defined to minimise impacts on groundwater.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction (temporary)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Chalk Principal aquifer	High	Chiltern tunnel Chalfont St Giles, Chalfont St Peter and Amersham vent shafts	Notwithstanding the mitigation measures set out within the draft CoCP, groundwater quality may be affected by increased turbidity, especially where construction takes place in layers of fissured Chalk. However, natural groundwater velocities are low and natural attenuation is likely.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	None	None	Not applicable

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Chalk Principal aquifer	High	Chiltern tunnel Chalfont St Giles, Chalfont St Peter and Amersham vent shafts Cross passages	Potential disruption to groundwater flow in the Chalk as a result of tunnels, vent shafts and cross passages. Due to the extent of the aquifer relative to the size of the tunnels, vent shafts and cross passages, groundwater flows are only likely to be locally affected by their presence. The hydrogeological maps of the area indicate that the Chilterns tunnel is roughly parallel to regional groundwater flow and consequently, is unlikely to form an obstruction to flow. Refer to Section 5.2 of this report for further discussion.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	None	None	Not applicable

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Chalk Principal aquifer	High	Chalfont St Giles, Chalfont St Peter and Amersham vent shafts land drainage areas	Two land drainage areas will exist above ground at each vent shaft. These will remove any surface water run-off from the hardstanding areas within the vent shaft compounds. The volume of water captured at these sites is likely to be very small as the hardstanding areas at the vent shafts will be approximately 500 – 600m^2. With such small volumes infiltrating the unsaturated zone and migrating to the Chalk water table and considering that the water infiltrating should not contain significant concentrations of potential pollutants.	Negligible impact Neutral effect (Not significant)	The draft CoCP refers to the guidance that will be complied with in order to ensure groundwater (or surface water) quality is not adversely affected.	Negligible impact Neutral effect (Not significant)	None	None	Not applicable

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Chalk Principal aquifer Head and River Terrace Deposits Secondary A aquifers	High (SPZ2 and SPZ3) Moderate	Stockpiles at Turners Wood, west of Upper Bottom House Farm and Whielden Lane.	There is potential for constituents arising from the excavated stockpiled material to reduce the quality of groundwater in the Chalk Principal aquifer and the Secondary A aquifers, where present. See Section 5.2 of this report for further discussion.	Moderate impact Moderate effect (Significant)	Suitable quality criteria will be defined prior to material being placed. The draft CoCP sets out the requirements about managing runoff from construction areas. This will reduce impacts on groundwater quality from runoff. Monitoring water quality will also be implemented as outlined in the draft CoCP.	Negligible impact Neutral effect (Not significant)	Not required	None	Construction (Permanent)
Chalk Principal aquifer	Very High in SPZ1	Stockpile of excavated material adjacent to the M25.	There is potential for constituents arising from the excavated material to reduce the quality of groundwater in the Chalk. See Section 5.2 of this report for further discussion.	Moderate impact Very large effect (Significant)	Suitable quality criteria will be defined prior to material being placed. The draft CoCP defines the controls and guidance that should be followed in order to obtain agreement with the Environment Agency to obtain an appropriate permit or exemption from permitting. Monitoring water quality will also be implemented as outlined in the draft CoCP.	Negligible impact Neutral effect (Not significant)	Not required	None	Construction (Permanent)
Abstractions									

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
PWS protected by Source Protection Zones TH027 and TH028	Very high	Chiltern tunnel Chalfont St Giles, Chalfont St Peter and Amersham vent shafts Cross passages	Tunnelling and piling/diaphragm wall construction has the potential to impact on groundwater quality. If fissures connect the working area of the Proposed Scheme directly to the Affinity Water groundwater abstraction, the impact of low levels of turbidity will be moderate due to the high quality required to be met for potable use, resulting in a large and significant effect. However, both these sources are significant distances down gradient from where the route crosses the aquifer zones supplying the abstraction (TH027 is over 4kms and TH028 is over 7kms). There is substantial opportunity for attenuation in the aquifer before groundwater flowing past construction reached the abstraction points. The likelihood of any impact is considered to be low.	Negligible impact Neutral effect (Not Significant)	Implementation of the draft CoCP will ensure that materials in contact with groundwater will be selected and method statements developed to control any potential contaminants. Monitoring will take place before, during and after construction until the groundwater quality has stabilised (to acceptable levels agreed with the Environment Agency). The monitoring data will be assessed and used to define appropriate mitigation, should it be required.	Negligible impact Neutral effect (Not Significant)	A management strategy will be developed with Affinity Water (and in agreement with the Environment Agency) to be put in place temporarily to ensure supplies to customers are not affected - these plans will cover all sources operated by Affinity Water.	Negligible impact Neutral effect (Not Significant)	Construction , temporary

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
PWS protected by Source Protection Zones Th011, Th171, TH181	Very high	Chiltern tunnel	Tunnelling and piling/diaphragm wall construction has the potential to impact on groundwater quality. If fissures connect the working area of the Proposed Scheme directly to the Affinity Water groundwater abstraction, the impact of low levels of turbidity will be moderate due to the high quality required to be met for potable use, resulting in a large and significant effect. TH181 is not shown to have an SPZ crossed by the route, but the route does pass very close to the point of abstraction and there is a high risk that any impact would be noted in the abstracted water. Both TH011 and TH171 are crossed close to the SPZ1 boundaries around the sources (ie. the travel time is not very significant between the route and the point of abstraction).	Moderate impact Large effect (Significant)	Implementation of the draft CoCP will ensure that materials in contact with groundwater will be selected and method statements developed to control any potential contaminants. Monitoring of yields and groundwater levels and quality will take place before, during and after construction until any impacts have been assessed. The monitoring data will be used to define appropriate mitigation, should it be required.	Moderate impact Large effect (Significant)	A management strategy will be developed with Affinity Water (and in agreement with the Environment Agency) to be put in place temporarily to ensure supplies to customers are not affected - these plans will cover all sources operated by Affinity Water.	Until the management strategy is agreed there is potentially a residual significant on public water supplied from these sources.	Construction , permanent

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Private abstractions (3 No.)	High	Chiltern tunnel	Private abstractions are lower yielding with smaller inner protection zones. The route will not pass within the inner or outer protection zones of any of the three private licensed groundwater abstractions identified in the study area[12]. Water quality may deteriorate.	Moderate impact Moderate effect (Significant)	Groundwater monitoring would be undertaken to determine the magnitude and extent of the effect and to inform the further mitigation applied.	Negligible impact Neutral effect (Not significant)	If required an alternative water supply will be provided	Negligible impact Neutral effect (Not significant)	Construction, temporary
Surface water/groundwater interaction and water dependent habitats									
River Misbourne Shardeloes Lake	High	Chiltern tunnel	Tunnel construction underlying the River Misbourne will result in settlement with a low risk of increased vertical permeability in base of River Misbourne potentially causing loss in flow. See section 4.2 of this report.	Negligible impact Neutral effect (Not significant)	Enhanced monitoring of lake water level, river flows to confirm low risk of loss of water from river.	Negligible impact Neutral effect (Not significant)	Bed sealing measures only if required.	Negligible impact Neutral effect (Not significant)	Construction, permanent

[12] The inner protection zone of a private water abstraction is defined as the 50-day travel time from any point below the water table to the source with a minimum 50m-radius and is equivalent to a PWS SPZ1. The outer protection zone of a private water abstraction is defined by a 400-day travel time from a point below the water table and equivalent to SPZ2 at a PWS.

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
River Misbourne Shardeloes Lake	High	Chalfont St Giles, Chalfont St Peter and Amersham vent shafts Cross passages	Times of travel for emergence of groundwater to surface water are likely to be longer than to public water supply boreholes under pumping conditions. Therefore, water quality issues within the groundwater are likely to diminish towards surface water receptors.	Negligible impact Neutral effect (Not significant)	No further mitigation considered necessary.	Negligible impact Neutral effect (Not significant)	None	None	Not applicable
River Misbourne	High	Vent shafts Cross passages	Dewatering of the vent shafts during construction may cause a reduction in flow in the River Misbourne.	Moderate impact Large effect (Significant)	Dewatering effluent will be returned to the aquifer through injection / recharge wells / areas adjacent to each shaft so there is no net abstraction and potential to impact on river flows.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction , temporary

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
River Misbourne and surrounding land at Chalfont St Giles	High	Chiltern tunnel	Potential to exacerbate occasional flooding of River Misbourne at Chalfont St Giles as a result of groundwater elevations mounding to overcome the tunnel as a potential obstruction to flow. However, the tunnel diameter is small in relation to overall thickness of Chalk aquifer so change in river flows will be negligible. See Section 5.2 of this report for further details	Negligible impact Neutral effect (Not significant)	No further mitigation considered necessary	Negligible impact Neutral effect (Not significant)	None	None	Not applicable

5.2 Detailed assessments

Effect of reduced aquifer thickness due to construction of lined tunnels

5.2.1 The construction of Chilterns tunnel as a fully sealed entity could affect groundwater flow up-hydraulic gradient of the tunnel as a result of the tunnel obstructing groundwater flow over the tunnel's height. The following calculation based on Darcy's Law indicates that the effect of lowering the effective transmissivity (by reducing the cross-sectional area of aquifer available for flow) will increase the groundwater elevation up-hydraulic gradient of the tunnel.

5.2.2 Darcy's Law Equation:

$$Q = K \times A \times i$$

- Where; Q is the aquifer flow (m^3/d);
- K is the hydraulic conductivity (m/d);
- A is the cross-sectional area of flow (m^2), which will reduce by the 10m height where the tunnel is proposed against a nominal original aquifer thickness of 50m; and
- i is the hydraulic gradient (i.e. $\triangle h \div \triangle L$ or the change in groundwater head (h) over the spatial length between head measurements (L)).

5.2.3 The tunnel will reduce the aquifer thickness from 50m to 40m. As such A (the flow zone of interest) would be reduced by 20%. With the same Q passing through the flow zone of interest, this requires a 25% increase in hydraulic gradient and a consequent slight increase in head over a length of 10m (i.e. the spatial length of the tunnel).

5.2.4 Taking the original hydraulic gradient between Amersham and Chalfont St Giles as around 10m in 2.7km (i.e. ignoring the fact that the tunnels run obliquely to the contours) as shown on the contours on the regional hydrogeology map, the increase in groundwater level required to force the same flow through the zone of reduced aquifer thickness across the two tunnels will be less than 9cm. This is considered to be too small to either change the current extent of groundwater flooding observed at Chalfont St Giles or the general pattern of groundwater flow across the study area and so the impact is assessed as negligible.

Effect of vent shafts on groundwater flow in CFA8

5.2.5 The impacts of vent shafts on groundwater flow are summarised in Table 10.

Table 10: Summary of impacts on groundwater flow due to vent shafts

Cutting name	Geology penetrated	Groundwater elevation	Effect on groundwater resources	Mitigation
Vent shafts	Partial penetration of the Chalk Principal aquifer	Water table will be above the base of the shafts	As the cross-sectional area of a vent shaft will be small in comparison with the overall aquifer dimensions, there will be neutral effect on groundwater flow. Any groundwater dewatered will be re-injected into the groundwater via recharge wells within the vicinity of the vent shaft with neutral effect on groundwater flow.	Not required

Impact to groundwater quality from deposition of stockpiles in the Chalfonts and Amersham area

5.2.6 The stockpile that will be adjacent to the M25 will have an area of approximately 6,000m^2 and will overlie the Chalk Principal aquifer and the SPZ1 for TH171. The Stockpile that will be at Turners Wood will be approximately 2,500m^2 and will overlie the Beaconsfield Secondary A aquifer which overlies the Chalk aquifer and the SPZ2 for TH171. The stockpile that will be west of Upper Bottom House Farm will have an area of approximately 16,500m^2 and will overlie the Chalk aquifer and consequently the SPZ2 for TH028. The stockpile that will be located at Whielden Lane will have an area of approximately 700m^2 and will overlie the Head Secondary A aquifer over the Chalk aquifer and consequently the SPZ3 for TH028.

5.2.7 As such, there is potential for groundwater quality to be adversely affected (by runoff of rainfall infiltrating through the stockpiles), particularly if there are fast pathways and fissures to the Chalk water table.

5.2.8 Suitable quality criteria for the material placed in the temporary stockpile will be defined prior to material being placed. The draft CoCP defines the controls and guidance that will be followed in order to obtain agreement with the Environment Agency to obtain an appropriate permit or exemption from permitting. The criteria will be determined to ensure that there is no significant degradation to groundwater quality as a result of the placement of material. The criteria will be agreed with the Environment Agency before placement of the material. The management of the material will be in accordance with the contaminated land: applications in real environments (CL:AIRE) code of practice[13] (as stated in the draft CoCP).

5.2.9 The material deposited in the stockpiles is considered to comprise natural, inert material and as such is unlikely to contain constituents that will adversely affect the

[13] Contaminated Land: Applications in Real Environments, (2011). *The definition of waste: Development industry code of practice*. Version 2, March 2011.

groundwater quality. Notwithstanding this the compliance criteria will provide a further level of security to protect groundwater quality since there will be small amounts of artificial materials remaining after centrifuging. These could comprise bentonite, polymers and other soil conditioners/ plasticisers or trace leakages of hydraulic oils and greases. The compliance criteria will take into account the amount of infiltration to the stockpile or percolation under the stockpile, site drainage design and the concentrations present in samples collected from the arising. Further treatments such as cement stabilisation may be applied subsequently depending on the eventual end use of the material.

5.2.10 It is concluded that there will be a negligible impact on groundwater quality in the Chalk and a neutral effect. A programme of groundwater monitoring, in coordination with monitoring at Affinity Water's PWS boreholes, will, however, be implemented to confirm this.

6 References

Atkins, (2007). *South West Chilterns Phase 1 Conceptual Model Final Report*. February 2007.

ARUP/URS (2012), *HS2 London to West Midlands Environmental Impact Assessment Scope and Methodology Report.*

Arup/URS (2013), *HS2 London to West Midlands Environmental Impact Assessment Scope and Methodology Report Addendum.*

Contaminated Land: Applications in Real Environments, (2011). The definition of waste: Development industry code of practice. Version 2, March 2011.

Department for Transport, (2013). *Design Manual for Roads and Bridges.* http://www.dft.gov.uk/ha/standards/dmrb/vol11/section3/hd4509.pdf

Environment Agency (2009) *River Basin Management Plan, Thames River Basin District.*

Land Drainage Act (1991), London, Her Majesty's Stationery Office.

Morigi et al., (2005). *Geology of the Beaconsfield District - A Brief Explanation of the Geological Map*; Sheet 255 Beaconsfield.

Murname, E., Heap, A. and Swain, A., (2006). *C648 Control of Water Pollution from Linear Construction Sites*. CIRIA, London, UK.

Environment Agency, (2009). *River Basin Management Plan, Thames River Basin District*.

European Parliament, (2000). *Water Framework Directive - Directive 2000/60/EC of the European Parliament and of the Council*. 23 October 2000 establishing a framework for Community action in the field of water policy, Strasbourg, European Parliament and European Council.

Water Resources Act (1991), London, Her Majesty's Stationery Office.